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Commentary

Principles for Thinking about Carbon Dioxide Removal in Just Climate Policy

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Carbon dioxide removal (CDR) is rising up the climate-policy agenda. Four principles for thinking about its role in climate policy can help ensure that CDR supports the kind of robust, abatement-focused long-term climate strategy that is essential to fair and effective implementation.

Carbon dioxide removal (CDR), sometimes called carbon removal or negative emissions, is the practice of capturing carbon dioxide from the atmosphere and storing it for long periods of time. There are many approaches to CDR, including nature-based solutions, such as ecosystem restoration, and more engineered approaches, such as direct air capture with carbon storage.[1] These encompass a variety of options for storing carbon, ranging from biomass and soils to oceans and geological reservoirs to long-lived products such as timber buildings or cement (Figure 1). CDR does not include fossil carbon capture and storage (CCS), such as CCS on a gas-fired power plant, or carbon capture and use that embeds carbon in short-lived products, such as synthetic fuels; they might reduce emissions, but neither of these technologies removes carbon dioxide from the atmosphere.

CDR is rising rapidly up climate-policy agendas because it could provide a useful—perhaps essential—supplement to emissions abatement as the world works toward meeting the Paris Agreement goals for limiting global warming.[2] As a result, civil society organizations, philanthropic funders, and government agencies are wrestling with the challenge of forming positions on CDR, including whether to support it at all and, if so, what mix of approaches to support, what kind of policies should govern it, and how to connect it to other elements of climate policy. The following four principles crystallize some of the key ideas that shape our own thinking about CDR. We present them here in the hope that others will find them useful as they deliberate about their own positions.

Don't Forget the Long Game

First, CDR is only one part of a long-term climate strategy. Cutting greenhouse gas emissions must remain at the center of that strategy: CDR would be too slow, expensive, and technically uncertain to replace the need for rapid emissions reductions.[3] Furthermore, attempting to do so would mean missing out on the social and environmental benefits of transitioning to clean energy. Adaptation, both incremental and transformative, also plays an essential role, as do measures to address loss and damage. The world needs to do all of these things to fight climate change—a "both/and" approach rather than "either/or."

Different people and institutions will have different expectations about long-term climate strategies. These include differences over the kinds of social, economic, and technological transformations that societies should or will use to decarbonize, the kinds of policies societies should adopt to spur those transformations, and the urgency and speed with which the world can completely decarbonize. These differences imply slightly different roles for CDR as part of the long-term strategy or different roles for different approaches to CDR at different times. In particular, some might see a role for CDR in mopping up residual emissions while we figure out how to decarbonize harder-to-abate sectors such as construction, heavy industry, and heavy transport. Others might prefer to limit CDR to compensating only for agriculture and land-use emissions or to use it after complete decarbonization to draw down "legacy carbon" remaining in the atmosphere from past emissions.

It turns out that these disagreements have relatively little impact on the question of whether to devote time and resources to CDR research, development, and deployment now. Even if the world can completely decarbonize quickly without

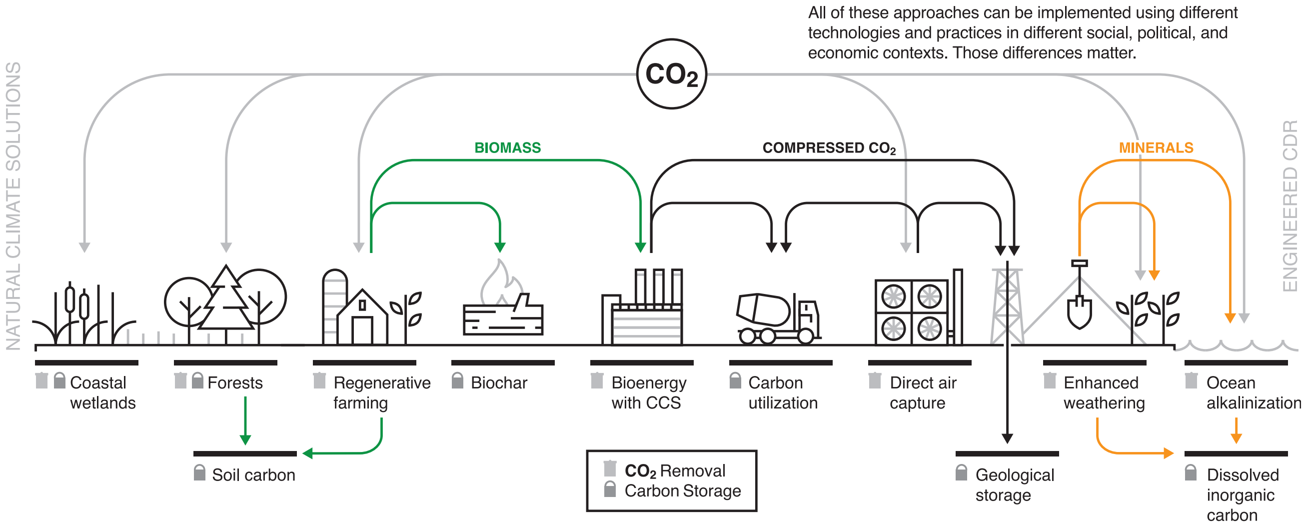

Figure 1. Some Proposed Methods of Carbon Dioxide Removal

Some of the many approaches that people have proposed for removing carbon dioxide from the atmosphere and storing it are presented here without assessment of their respective potential for removing or storing carbon or their social, environmental, or economic sustainability, which will vary between methods and depend on the details and context of implementation. These methods are often divided into "natural climate solutions" and "engineered" approaches, although the precise boundary between these categories is contested and somewhat vague. Illustration by Matt Twombly.

CDR, almost any path to decarbonization still leaves the world facing dangerous climate impacts.[2] By cleaning up legacy carbon, CDR could lower carbon dioxide concentrations and reduce climate risk, though lowering concentrations significantly would require removing hundreds of billions of metric tons of carbon dioxide.[4]

To reach that scale, societies can begin rolling out some approaches now, such as ecosystem restoration, informed by decades of experience at the intersection of land management and climate policy. Other approaches, such as enhanced mineralization, require further research, development, demonstration, and deployment. Whatever mix of approaches societies adopt, scaling up CDR capacity to the multi-gigaton scale, if feasible, would take several decades.[5] Therefore, if we want to remove hundreds of billions of metric tons by the end of this century, whether as part of a net-zero strategy or to clean up legacy carbon,[6] now is the time to begin developing and adopting appropriate policies for CDR research, development, and rollout.

At the same time, thinking only about the long game isn't enough. Reducing emissions and adapting to climate change must remain top priorities in the near term.

It's Not All about the Carbon

Second, social, economic, and environmental impacts matter. Different approaches to CDR have different resource requirements and different social and environmental impacts.[1,7] Whether it is an individual farmer adopting cover-crop rotations or a large corporation building a direct air capture facility, the value of any CDR project depends not just on whether and how much carbon it can sequester at what financial cost but also on the project's environmental, social, and political impacts. In some cases, especially with natural climate solutions, positive impacts could justify adoption independently of the climate benefits. In others, negative impacts could outweigh any climate benefits. In all cases, those impacts depend on the context and details of the project and not just on the particular technology or practice in question. For example, compare a small bioenergy with carbon capture and storage (BECCS) facility fueled by local municipal waste with a BECCS system in which huge swathes of commercially farmed land provide switchgrass to fuel large power plants that pipe carbon dioxide long distances for sequestration. These two approaches would have very different impacts, which could include impacts on land use, water use, infrastructure needs, food prices, and biodiversity. Evaluating CDR at the level of broad technologies or practices obscures these differences. As a result, technology-level assessments tend to focus on things that can be calculated in the abstract, such as cost and total carbon sequestered. Those aspects of CDR matter, but a complete assessment of CDR requires assessing not only cost and sequestration potential but also environmental and social impacts.

Three questions about social and political context deserve special attention. The first is whether a particular project, program, or policy comports with equity and the principle of common but differentiated responsibility and respective capabilities. CDR is fundamentally about cleaning up pollution. It makes sense for polluters to pay for it and to have excess costs fall on those who are best able to bear them. It would be patently unfair for the Global North to pass the responsibility for cleaning up carbon pollution to the Global South, which contributed much less to the problem. Some observers worry that the very corporations that contributed so much to carbon pollution could use CDR to evade accountability, but it could be that assigning these corporations responsibility to undertake or finance CDR offers a way to hold them accountable. Thus, a key social and political question about any CDR undertaking is the extent to which the costs and the social and environmental burdens associated with it fall on those who bear the greatest responsibility for the problem.

The second question is about the overall political and economic context in which

CDR would be deployed in the future. Many civil society organizations argue that nothing short of radical social transformation will enable us to stop climate change, and some fear that CDR would be used to delay that transformation. But a vast, decades-long carbon-clean-up operation would look very different after a radical social transformation than it would in the current political and economic climate. Moreover, because CDR at the multi-gigaton scale would require vast infrastructure and because some options, such as direct air capture, assume widespread cheap renewables, large-scale CDR implies widespread voter willingness to fund carbon clean-up and deep decarbonization, making CDR a consequence of social transformation, changed values, and renewables deployment rather than an obstacle to them.[8] We might need to stretch our imaginations to envision economic and political futures in which CDR fits into the world we want rather than delaying or undermining it.

The third question is about the level of transparency included or required for any given CDR undertaking. It is difficult to assess an undertaking's social, economic, and environmental impacts without adequate transparency, making transparency essential for effective and legitimate decision making.

Split, Don't Lump

Third, assessing CDR requires going beyond technology-level analyses. This follows from the second principle. Not all carbon removal is created equal in terms of social, economic, and environmental impacts, and nuanced positions are needed to distinguish better technologies, practices, projects, and policies from worse ones.

Broad categories, such as those in Figure 1, usefully convey the breadth of options for CDR, but they also conceal important differences between specific technologies and practices. For instance, forest restoration and monoculture tree plantations might both fall under the heading of reforestation, but only the former can promote adaptation, preserve biodiversity, and deliver long-term carbon storage.[9] As another example, spreading finely ground basalt on cropland and scattering olivine pebbles on coastal seabeds both count as enhanced weathering, but the former requires far more energy to grind the rocks, and the two approaches involve very different social, economic, and environmental systems.

Furthermore, the social, economic, and political contexts in which people implement CDR will affect its acceptance and impacts. For example, consider a direct air capture facility financed by fossil fuel companies or a petrostate. Some would regard such a facility's fossil fuel financing as unforgivable. Distinguishing between different projects and different contexts, however, allows those who oppose fossil fuel financing to take a nuanced position that opposes that particular project while leaving open the possibility of direct air capture projects that operate free from fossil fuel influence in a context of transparency and good governance. That makes it important to assess CDR on a case-specific basis rather than just as abstract technologies. It is only at this level that organizations can distinguish between bad *technologies or practices* and bad *projects* by accounting for the environmental, social, political, and governance contexts of specific projects.

In short, fine-grained analyses of carbon-removal projects, programs, or policies allow us to avoid throwing the good out with the bad or allowing the bad in with the good. By analogy, support for emissions reductions doesn't automatically translate into support for every strategy that would cut emissions.[10] Some see some kinds of low-carbon energy as better than others, and many outright oppose certain technologies or practices, such as nuclear power plants or large hydroelectric dams, because of costs, risks, or impacts on vulnerable communities and ecosystems. It is even possible to support a particular technology while opposing specific projects. For example, an organization might support policies to incentivize development of solar energy while opposing a specific project because it is sited on high-value biodiversity land. CDR deserves the same nuanced analysis.

Don't Bet It All on Being Right

Fourth, climate policy needs to be resilient against unexpected outcomes. The long-term scenarios that the Intergovernmental Panel on Climate Change analyzed for its Fifth Assessment Report in 2014 and its Special Report on the impacts of global warming of 1.5°C relied heavily on vast plantations of bioenergy crops for BECCS to keep warming below 2°C or 1.5°C.[2,11] Critics noted that counting on future CDR in this way puts future generations' well-being at risk: if large-scale CDR never emerges, for whatever reason, then future generations will find themselves saddled with dangerous levels of atmospheric carbon dioxide.[12] We agree that precaution precludes us from betting it all on CDR's panning out as the models project. We also worry about making the opposite mistake by counting only on rapid emissions abatement: if the world fails to decarbonize quickly, for whatever reason, or if we decarbonize quickly but the climate does not respond as we expect, then future generations could find themselves saddled with dangerous levels of carbon dioxide. Robust, flexible, precautionary climate policy requires recognizing that, despite our best-laid plans, future generations might benefit from large-scale CDR in the second half of this century. Ensuring that large-scale CDR is a possibility by mid-century means beginning research and development now. Playing "wait and see" with CDR could leave us with several extra decades of global heating that could have been avoided and an increased risk of crossing climate tipping points.

Why It Matters

What's at stake in making the right call on CDR? We worry about three things with respect to CDR: societies could do too little, they could do too much, or they could do it wrong. On the one hand, if the world does not devote enough time and resources to developing and deploying CDR, we will face higher carbon dioxide concentrations—and therefore a more dangerous climate—than necessary. On the other hand, societies that pursue CDR at too large a scale, adopt the wrong mix of approaches for their circumstances, or govern CDR ineffectively could face serious social and environmental downsides. By engaging thoughtfully with CDR on the basis of the principles we have outlined, civil society organizations, funders, and government agencies can help ensure that CDR plays a positive role in the kind of robust, abatement-focused long-term climate strategy that is essential to fair and effective climate policy.

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